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Biomass energy in Malaysia: Current state and prospects

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ABSTRACT

Today, energy crisis turn out to be a serious threat towards sustainability for developing countries since their energy demand is growing more rapidly than developed countries. On the other hand, fossil fuels cannot sustain anymore in the near future because of environmental impacts and depletion of the reserves. Malaysia is experiencing drastic growth in population and economy and requires exploring alternative energy sources to support its population and commercial energy demand. Biomass as the fourth largest energy resource in the world is abundant in the country. Malaysia is blessed with tropical and humid climate all year round which is a magnificent opportunity for fully exploiting agriculture and tropical forests potential. Since late 1990, the concept of waste-to-wealth had been promoted and became popular widely. This concept is based on unwanted wastes which are converted into valuable energy while reducing waste generated and increase the economy-efficiency mainly used for cooking, space heating and power generation. Currently, concerted efforts and various biomass energy programs are supporting by the government for development, demonstration and commercialization. This paper intent to present the current state and prospects of biomass utilization and strategies promoted for future developments in Malaysia.

Contents

1. Introduction

Energy crisis has become a serious threat towards sustainability mostly for developing countries and communities in the last decades. During 1990–2000, developing countries of the Asia Pacific region met 27% increase in conventional energy consumption while the world energy consumption was 11% [1]. Increasing in the energy demand is expected to continue in the future. Fossil fuels have been the main source of energy since first sparks of technology appeared in mankind lives, however, depletion of fossil fuel reserves as well as significant environmental impacts, leads the governments and authorities to focus on renewable energy resources. In most recent years, demand for petroleum-derived fuels is increasing as a result of grow in population and economy

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Nomenclature

FDP	Fuel Diversification Policy
GDP	Gross Domestic Product
EC	Energy Commission
TNB	Tenaga Nasional Berhad
SESB	Sabah Electricity Sdn. Bhd.
SESCO	Sarawak Energy Supply Corporation
DoE	Department of Environment
EFB	Empty fruit bunches
MF	Mesocarp fiber
MOP	Molded oil palm
MSW	Municipal solid waste
LFG	Landfill gas
GHG	Greenhouse gases
UN Agenda 21	United Nations Agenda 21
SD	Statistic Department
GWP	Global Warming Potential
CDM	Clean Development Mechanism
JI	Joint Implementation
COP7	Conference of the Parties the 7th Session
CER	Certified Emission Reductions
PTM	Malaysia Energy Centre
PKE	Palm kernel expeller
NG	Natural gas
BTG	Biomass Technology Group
MPOB	Malaysian Palm Oil Board
FPISB	Felda Palm Industries Sdn. Bhd.
CPO	Crude palm oil
SREP	Small Renewable Energy Power
REPPA	Renewable Energy Power Purchase Agreement
SCORE	Special Committee on Renewable Energy
BioGen	Biomass-based Power Generation and Co-generation
UNDP	United Nationals Development Program
USD	United State Dollar
GEF	Global Environment Facility
FiT	Feed in Tarif
TSHRB	TSH Bio-Energy
UKM	University Kebangsaan Malaysia
USM	University Science Malaysia
UPM	University Putra Malaysia
UM	University Malaya
UTM	University Technology Malaysia
UTP	University Technology Petronas
IUU	International Islamic University
POME	Palm Oil Mill Effluent
RE	Renewable energy

Subscripts

ktonnes	kilotonnes
km^2	square kilometre
ha	hectares
%	percentage
boe	barrels of oil equivalent
m^3	cubic metre
CH_4	methane
CO_2	carbon dioxide
N_2O	nitrous oxide
SF_6	sulphur hexaflouride
HFC	hydrofluorocarbon
PFC	perfluorocarbon
kg	kilogram
B5	biodiesel fuel blend
MW	megawatt
C_5	pentoses
C_6	hexoses
kWh	kilowatt hour
RM	Ringgit Malaysia
°C	degree Celsius
g	gram

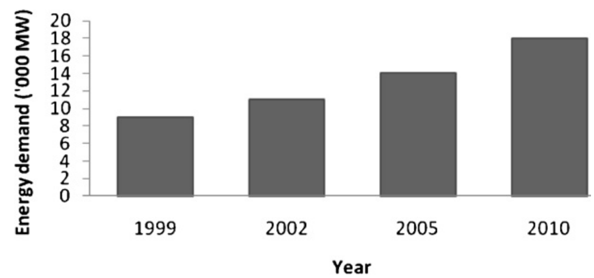

Fig. 1. Predictions of energy demand in Malaysia [4].

[2]. As economy grow, energy demand increases and brings along some changes in the energy consumption pattern which in turn varies with the source and availability, conversion loss and end use efficiency [3].

Fig. 1 illustrates the energy demand for Malaysia has been predicted in. It can be seen that the energy demand in Malaysia increases almost 20% between 1999 and 2002. And the energy demand is estimated to increase to 18,000 MW by 2010 [4].

Conventional fuels are limited and will not be able to sustain for another 100 years [5]. Therefore, somehow, other renewable petroleum-derived should be revealed as a backup energy and the most similar to the petroleum-derived is biomass energy. Global warming issues, environmental impacts and depletion of fossil fuel resources play important roles to improve the prospects of biomass energy technologies and consumption in the future. Biomass energy is the preeminent substitute to petroleum-derived energy and is suitable as a backup energy for sustainable energy development.

1.1. Energy and biomass

1.1.1. Energy status in Malaysia

Malaysia is well endowed with both fossil and renewable energy sources and has successfully controlled the country's demand for energy [6]. Table 1 presents types of the renewable energy resources in Malaysia, and energy value in Ringgit.

As it shows, renewable energy sources are widely available in the country. Despite its wide use already, there is still much to be done to optimize the utilization of renewable energy in Malaysia.

Table 1
Types of renewable energy in Malaysia and its energy value [7].

Renewable energy source	Energy value in RM million (annual)
Forest residues	11,984
Oil palm biomass	6379
Solar thermal	3023
Mill residues	836
Hydro	506
Solar PV	378
Municipal waste	190
Rice husk	77
Landfill gas	4

Table 2
Renewable energy potential in Malaysia [8].

Renewable energy	Potential (MW)
Hydropower	22,000
Mini-hydro	500
Biomass/biogas (oil palm mill waste)	1300
Municipal solid waste	400
Solar PV	6500
Wind	Low wind speed

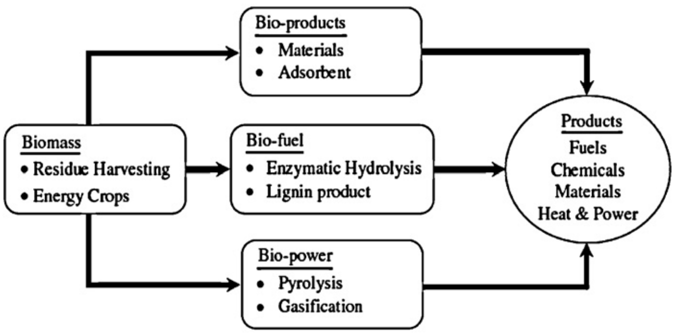

Fig. 2. Biomass initiatives as renewable energy [7].

Table 3
Energy mix in Malaysia (%) [8,10].

Source	1980	1990	2000	2005	2010
Oil/diesel	87.9	71.4	4.2	2.2	0.2
Natural gas	7.5	15.7	77.0	70.2	55.9
Hydro	4.1	5.3	10.0	5.5	5.6
Coal	0.5	7.6	8.8	21.8	36.5
Biomass	–	–	–	0.3	1.8

Table 2 is a summary of renewable energy potential to generate power in Malaysia ultimately. Hydropower and solar PV are the best sources with highest potential due to Malaysia's geographical situation with plenty of rivers and sunlight all year round.

Presently, continuous efforts and researches are focused on biomass as an alternative for power generation. Whereby numerous agricultural and forest residues are turned out to be useful energy and applicable products. Fig. 2 depicts the scope of biomass initiatives as renewable energy [7].

The 5th Fuel Diversification Policy (FDP) was introduced in 1999 [9]. It defines the energy mix by 5 main resources as: gas, coal, oil, hydro and renewable energy. The introduction of FDP was to reduce Malaysia's over-reliance on specific fuel type and to achieve a more balanced supply mix between natural gas, oil, coal and hydropower (plus other minor renewable energy in the 5th FDP). In line with 5th Fuel Diversification Policy (FDP), Malaysian government has taken an effort in reducing the dependence on conventional energy resources by utilising them efficiently while increasing the use of alternative renewable energy sources [10]. Direct consequence from this strategy saw the contribution of oil in the energy mix dropped drastically from a high 87.9% in 1980 to 4.2% in 2000 as shown in Table 3, and projected to drop below 1% by 2010 [8].

Malaysia is embarking on a gradual change of fuel consumption from depending solely on specific sources to a mix of fuel sources derived from hydropower and coal [11]. Based on the 9th Malaysia Plan (2000–2010), the use of oil, gas and hydro had declined from 4.2% to 0.2%, from 77% to 55.9% and from 10% to 5.6%, respectively. However, the hydro power generation most increase for Sabah and Sarawak from 21.3% (in 2000) to 26.5% (in 2010) and from 14.3% (in 2000) to 31.7% (in 2010), respectively. On the other hand, the generation of energy from coal rose drastically from 8.8% to 36.5%.

Table 4
Fuel mix in electricity generation, 2000–2010 [10,11].

Year	% of total					Total (GWh)
	Oil	Coal	Gas	Hydro	Others	
Malaysia						
2000	4.2	8.8	77.0	10.0	0.0	69,280
2005	2.2	21.8	70.2	5.5	0.3	94,299
2010	0.2	36.5	55.9	5.6	1.8	137,909
TNB						
2000	2.3	8.7	79.6	9.4	0.0	63,634
2005	0.5	22.5	71.9	4.9	0.2	86,242
2010	0.1	38.1	56.8	3.4	1.6	126,718
SESB						
2000	47.3	–	31.4	21.3	–	2299
2005	42.6	–	43.0	13.6	0.8	3447
2010	0.5	18.5	47.2	26.5	7.3	4808
SESCO						
2000	11.2	15.1	59.4	14.3	–	3347
2005	4.7	25.0	58.9	11.4	–	4610
2010	3.0	21.2	44.1	31.7	–	6383

Table 4 is the fuel mix in electricity generation during 2000–2010. It shows that government's strategy to reduce its over-reliance from oil and gas to coal and hydro power is achievable on a gradual basis.

Traditionally, Malaysia had been relying on its agriculture productions as a source of wealth and had developed as a leading agricultural country in the world. Being an agricultural based economy, Malaysia was involved in the crops cultivation, rearing of livestock and fishery. However, changes in the lifestyle of the people, as a result of urbanization and higher level of income, have resulted in changes in eating habits, food purchasing and consumption patterns [12]. The changes are reflected in the population, the economy activities (which contribute to economy sector) and energy demand, which had a positive impact on the GDP (Gross Domestic Product) of Malaysia. According to Department of Statistics, the population in Malaysia has raised from 27.17 million to 28.31 million in 2009.

GDP is known as an indicator of the average standard living of individuals in the country and economic growth (which means the increase in value of goods and services produced by an economy). GDP measures the national income and output for the country's economy [13]. According to [14], the real GDP is calculated by the real GDP per capita multiplying by the population. Meanwhile, the energy consumption primarily based on the country's production, exports and imports of various energy carriers and electricity production [14].

Malaysia consists of 13 states, 1 federal territory (Wilayah Persekutuan) with 3 cities: Kuala Lumpur, Labuan and Putrajaya [15]. The GDP per capita by annual percentage growth and percentage share to Malaysia GDP in 2007 for each state are summarized in Table 5.

From Table 5, the top 5 contributors to the national GDP in 2007 are Selangor, WP Kuala Lumpur, Sarawak, Johor and Pulau Pinang. It is clearly derived that the main contributor to the GDP is Selangor with 21.5%, followed by WP Kuala Lumpur (13.8%), Sarawak (9.6%), Johor (9.5%) and Pulau Pinang (8.8%). Total national GDP in the country is 63.2%, however, WP Kuala Lumpur shows highest growth of GDP at 9.0%. Table 6 provides type of economy activities for each state in 2007.

The highest contributor to Malaysian economy is services sector constituting 51.6% of total output, followed by manufacturing (28.6%), mining and quarrying (8.5%), agriculture (7.5%), construction (2.7) and import duties (1.1%).

For the services sector, WP Kuala Lumpur shows the highest GDP with 23.8% over Malaysian services sector, followed by Selangor with 23.1% of GDP, Johor (8.9%), Pulau Pinang (7%) and Perak (6.6%). Total national GDP in the services sector is about 69.4%.

Table 5
The GDP per capita by state, annual percentage growth and percentage share to Malaysia GDP 2007 [16].

States	GDP per capita (current prices; RM)	Annual percentage growth (constant prices; %)	Percentage share to Malaysia GDP (constant prices; %)
Johor	17,802	3.3	9.5
Kedah	11,657	8.7	3.6
Kelantan	6821	7.5	1.7
Melaka	22,288	6.3	2.8
Negeri Sembilan	24,233	5.6	3.7
Pahang	19,111	2.4	4.5
Pulau Pinang	32,376	6.6	8.8
Perak	14,703	5.8	5.3
Perlis	14,458	6.5	0.6
Selangor	24,584	7.6	21.5
Terengganu	15,883	6.5	2.8
Sabah	12,583	4.5	5.5
Sarawak	29,175	6.5	9.6
WPKL	49,336	9.0	13.8
WP Labuan	27,981	5.1	0.5
Supra State[a]	..	1.6	5.9
Malaysia	23,544	6.2	100.0

Data for year 2007 is preliminary data.
[a] Supra State covers production activities that beyond centre of predominant economic interest for any states in Malaysia.

Meanwhile, in manufacturing, Selangor is the main contributor with the GDP of 26.6%, followed by Pulau Pinang (16.8%), Johor (12.4%), Sarawak (9.7%) and Negeri Sembilan (6.7%). The total of these states contribute to 72.2% of total manufacturing sector for Malaysian economy.

Sabah and Sarawak are the major contributors for mining, quarrying and agriculture sector with RM2, 286 million and RM10, 153 million, respectively. They also have contributed in agricultural sector by 21.2% and 19.8%, respectively. This is followed by Johor with GDP of 12.4%, Pahang (10.3%) and Perak (10.2%). The total of these 5 states constitutes about 73.9% of the total agriculture production in Malaysia. In the construction sector, Selangor contribute the major GDP with 37.6%, followed by WP Kuala Lumpur (15.4%), Johor (10.2%) and Sarawak (7.7%). These 4 states contribute 70.9% of GDP in construction sector for the country's economy.

The growth in population will lead to changes in eating habits, food purchasing and consumption patterns of a nation, which has direct effect on the individual life styles, affecting the component of economic activities and hence the GDP of the country. There is a positive correlation between population growth and energy demand. Growth in economy, correspond to growth in energy demand thus resulting to changes in consumption of energy pattern. This in turn enquires the government to explore alternative energy sources to support its population. Nevertheless, urbanization leads to high production of wastes, and the government can explore to harness these waste as a new alternative source of energy in the future [3,12].

1.1.2. Segregation in energy sector

Ministry of Green Technology (KeTTHA) is responsible to formulate economic policy planning and technical policy planning. Petronas is responsible to manage the resources, whereas in industrial category, Energy Commission (EC) gas retailer is responsible to regulate sales of gas. In terms of transportation, the Ministry of Transport is in charge. Meanwhile for the electricity industry, Energy Commission, Tenaga Nasional Berhad (TNB), Sabah Electricity Sdn. Bhd. (SESB) and Syarikat SESCO Bhd. which was formerly known as Sarawak Energy Supply Corporation (SESCO) are responsible to regulator supplier of electricity. The monitoring of pollution is undertaken by Department of Environment (DOE) [17].

1.2. Biomass categorization

There are a variety of biomass energy resources such as agricultural wastes, forest residues and urban wastes. Table 7 provides the quantity of biomass produced in Malaysia in 2007.

2. Biomass energy utilization in Malaysia

2.1. Agricultural wastes

Power generation from agricultural wastes seems to be very attractive due to bio-resource sustainability, environmental concerns and economic reflection. Malaysia is a leader as one of the foremost agricultural countries in the world. It is main agricultural crops are oil palm, rubber, cocoa, rice and coconut; however, 2 major agricultural resources are oil palm and rubber with combine acreage of over 330,000 km^2 [2], hence Malaysia government has targeted to generate energy from by-product and residues of 362 palm oil mills in the country. Malaysia, as the first palm oil producer in the world, is processing 71.3 million tonnes/year of fresh fruit bunch. The result is derivation about 19 million tonnes/year of crop residues consist of empty fruit bunch, fiber and shell. Table 8 shows the quantities of oil palm residues which have potential of gener-

Table 6
GDP by state and kind of economy activity 2007 [16].

Constant year 2000 prices	Agriculture	Mining and quarrying	Construction	Manufacturing	Services	Plus: import duties	Total (RM million)
Johor	4697	59	1412	17,946	23,097	833	48,044
Kedah	1765	25	474	7128	8593	96	18,081
Kelantan	1873	16	129	366	6184	15	8583
Melaka	561	10	372	6841	6109	8	13,901
Negeri Sembilan	1194	19	385	9765	7284	43	18,691
Pahang	3892	37	456	7077	11,147	5	22,614
Pulau Pinang	802	13	730	24,274	18,182	264	44,264
Perak	3854	87	425	5489	17,109	22	26,986
Perlis	825	18	66	304	1469	102	2784
Selangor	1501	158	5188	38,384	60,217	3079	108,527
Terengganu	1235	15	532	4793	7524	25	14,125
Sabah	8029	2286	422	2543	14,445	120	27,844
Sarawak	7483	10,153	1061	14,033	15,644	167	48,540
WPKL	44	27	2126	4834	61,951	733	69,713
WP Labuan	92	..	12	646	1542	10	2303
Supra State[a]	..	29,919	..	...	..	..	29,919
Malaysia	37,846	42,842	13,791	144,423	260,496	5521	504,919

Data for year 2007 is preliminary data.
[a] Supra State covers production activities that beyond centre of predominant economic interest for any states in Malaysia.

Table 7
Quantity of biomass produced in Malaysia in 2007 [2].

Types	Quantity (ktonnes)	Source	Source (ktonness)	MC (wt%)	DW (ktonnes)
Agricultural waste					
Oil palm fronds	46,837	Oil palm FFB	81,920	60.0	18,735
EPFB	18,022			65.0	6308
Oil palm fibers	11,059			42.0	6414
Oil palm shells	4506			7.0	4190
Oil palm trunks[a]	10,827			75.9	2609
Paddy straw	880	Replanting paddy	-	11.0	783
Rice husk	484		2375	9.0	440
Banana residues	530	Banana	265	10.7	473
Sugarcane bagasse	234	Sugarcane	730	50.0	117
Coconut husk	171	Coconut	505	11.5	151
Pineapple waste	48	Pineapple for factories	69	61.2	19
Forest residues					
Logging residues	2649	Logs	2649	12.0	2331
Plywood residues	2492	Plywood	2492	12.0	2193
Sawmill residues	1160	Sawn timber	1418	12.0	1021
Municipal solid waste					
Organic waste (all organic materials including food waste and paper cardboards)	4653	MSW	6744	57.5	1978

Table 8
Types of biomass and quantity produced [7].

Type of biomass	Quantity/annum (MT)
Empty fruit bunch (EFB)	15.8
Fronds	12.9
Mesocarp fiber (MF)	9.6
Trunk	8.2
Shell	4.7

ating energy. Empty fruit bunch (EFB) and mesocarp fiber (MF) are the utmost contributors of oil palm biomass with around 15.8 and 9.6 MnT production/year, respectively [7]. The EFB and MF can be processed under heat and pressure to produce molded oil palm (MOP), which is a distinctive bio-based material extremely useful in furniture, building, electronics, packaging, and automobile industries. Table 9 shows the calorific values and moisture content of these residues [4,7,18].

Oil palm or its scientific name *Elaeis guineensis* is the most important species in *Elaeis* genus which belongs to the family of *Palmae* [20]. The main application of palm oil is in food industry and as a new source of raw material of bio-diesel fuel [21]. According to Malaysian Palm Oil Board, the planting area for oil palm has increased from 4,304,914 ha (in 2007) to 4,487,957 ha (in 2008). Total export of oil palm has been increased from 19,574,242 tonnes (in 2007) to 21,750,074 tonnes (in 2008). Table 10 shows a summary on the performance of Malaysia oil palm industry in 2007 and 2008, while Table 11 shows the acreage (ha) under oil palm (mature and immature) by states in Malaysia.

Other biomass source from the agricultural industries included cassava, corns, corn straws, rice husks, paddy straws, cocoa, coconut, and sugarcane residues Paddy cultivation is concentrated in Kedah and Selangor. In 2006, 2128 million tonnes of rice was produced. However, the production of paddy straw and rice husk is only 1–3 times per year (comprising of 1.5% of the country's energy consumption in 1996) during the harvesting seasons. With regard to coconut cultivation, land area for coconut cultivation is declined from 350,000 ha in 1975 to 249,000 ha in 1995 [19].

Table 9
Calorific values and moisture content of palm oil residues [19].

Residue	Calorific value (kJ/kg)	Moisture content (%)
Empty fruit bunch	6028	60
Fiber	11,344	40
Shell	18,836	20

Coconut wastes are in the form of fronds and debris that are generated from the processing and consumption of coconut fruits, and also the wastes that are generated during the replanting of the coconut trees. The land area for cocoa cultivation also declined from 452,000 ha in 1991 to 235,000 in 1996. The cocoa wastes are mainly generated during the pruning process, another wastes are generated from cocoa leaves and woody biomass during replanting. The pruning process is a process whereby the cocoa trees are trim in order to keep its height within 3–4 m; however, this process is not accepted anymore due to detrimental effects to the trees. According to [19], in 1996, 17 million barrels of oil equivalent (boe) of energy were available, but was not harvested.

Sugarcane cultivation is exclusively throughout the dry season, especially in the northern states of Peninsular Malaysia. The total cultivated area was about 18,600 ha in 1976. By 1980, the cultivated area of sugarcane expanded to 20,300 ha; however, the acreage declined in 1997 to approximately 18,000 ha [19]. Sugarcane cultivation produces granulated sugar, molasses, bagasse, dry leaves of sugarcane trees and cane tops. 30% of the sugarcane cultivation produces bagasse, but the main production is granulated sugar.

In Table 12, the main sources of wastes from the agricultural sector in 2000 are summarized, while Table 13 provides the agricultural land use between 1995 and 2010 ('000 ha) in Malaysia. Comparing two tables indicates that major production of the agricultural sector had been rubber wood residues and turned into oil palm since 1995 [18].

2.2. Forest residues

The total land area in Malaysia is 32.90 million ha [24]. The land area under natural forest and agricultural sector is tabulated in Table 14.

Malaysia produces large volume of wood mass which has a huge renewable energy potential; however, only 60–65% of the residues have been harvested for energy [19]. The remaining percentage is left to rot or burn to waste. The forest residues which are mainly consist of woods and straws are generated from pulp and paper industries [2]. Table 15 shows the quantity export of major timber in Malaysia by 2007 and 2008.

In Malaysia, there are 4 types of forest residues which are logging residues, saw milling residues, plywood and veneer residues and the secondary processing residues [19].

Table 10
A summary on the performance of the Malaysian Oil Palm Industry 2007 and 2008 [22].

	2007	2008	Different (%)
Planting (ha)			
Area	4,304,914	4,487,957	4.3
Production (tonnes)			
Crude palm oil	15,823,368	17,734,439	12.1
Palm kernel	4,096,613	4,577,500	11.7
Crude palm kernel oil	1,907,613	2,131,399	11.7
Palm kernel cake	2,152,488	2,358,732	9.6
Oleochemical products	2,140,295	2,207,994	3.2
Exports (tonnes)			
Palm oil	13,746,823	15,408,753	12.1
Palm kernel oil	1,060,713	1,047,380	−1.3
Palm kernel cake	2,093,500	2,255,092	7.7
Oleochemical products	2,140,173	2,072,221	−3.2
Biodiesel	95,013	182,108	91.7
Finished products	351,183	670,569	90.9
Others	86,839	113,951	31.2
Total Exports (tonnes)	19,574,242	21,750,074	11.1
Closing stocks (tonnes)			
Palm oil	1,682,587	1,994,681	18.5
Palm kernel	170,539	142,071	−16.7
Palm kernel oil	268,842	348,747	29.7
Palm kernel cake	289,357	302,278	4.5
Imports (tonnes)			
Palm oil	267,571	561,035	109.7
Palm kernel oil	264,765	221,391	−16.4
Export revenue (RM million)			
Palm oil	33,186.7	47,917.6	44.4
Palm kernel oil	3104.9	4159.8	34.0
Palm kernel cake	761.7	990.0	30.0
Oleochemical products	6679.6	8695.3	30.2
Biodiesel	253.2	610.7	141.2
Finished products	1098.3	2656.5	141.9
Others	84.7	164.5	94.2
Total revenue (RM million)	45,169.1	65,194.3	44.3
Prices (RM/tonnes)			
Fresh fruit bunches (1% OER)	26.07	30.16	15.7
Palm kernel (Ex-Mill)	1461.50	1647.00	12.7
Crude palm oil (local delivered)	2530.50	2777.00	9.8
Crude palm kernel oil (local delivered)	2807.50	3437.00	22.4
RBD palm oil (FOB)	2640.00	2699.00	2.2
RBD palm olein (FOB)	2588.00	3055.00	18.0
RBD palm stearin (FOB)	2511.50	2551.00	1.6
PFAD (FOB)	1931.50	1674.00	-13.3
OER (%)			
Malaysia	20.13	20.21	0.4
Peninsular Malaysia	19.32	19.61	1.5
Sabah	21.25	21.07	-0.8
Sarawak	21.03	21.05	0.1
Yield (tonnes/hectares)			
FFB	19.03	20.18	6.0
OIL	3.83	4.08	6.5

Table 11
Area under oil palm by states (mature and immature) in 2007 (ha) [22].

State	Mature	Immature	Total
Johor	595,524	75,117	670,641
Kedah	71,934	3162	75,096
Kelantan	79,146	20,617	99,763
Melaka	45,816	3297	49,113
Negeri Sembilan	149,879	20,964	170,843
Pahang	563,809	77,643	641,452
Pulau Pinang	13,010	294	13,304
Perak	323,535	27,448	350,983
Perlis	258	2	260
Selangor	120,563	8752	129,315
Terengganu	135,911	25,376	161,287
Peninsular Malaysia	2,099,385	262,672	2,362,057
Sabah	1,151,698	126,546	1,278,244
Sarawak	513,306	151,306	664,612
Sabah/Sarawak	1,665,004	277,852	1,942,856
Malaysia	3,764,389	540,524	4,304,913

Table 12
Quantity of residues generated by the agricultural sector in 2000 [17].

Source	Million m^3
Rubberwood residues[a]	11.32
Oil palm residues	8.69
Rice husk residues	3.41
Total	23.42

[a] Based on an extraction rate of 100.5 tonnes/ha and excluding residues left behind durinng program.

Logging residues are produced during the various phases of logging operations in the form of bark, stumps, tops, branches, broken logs and injured standing trees. Saw milling residues, are mostly generated within the processing activities in saw mill in the form of sawdust, off-cuts, slabs, shavings and bark in which 65–70% of total biomass harvested trees end up as residues [19]. Meanwhile, in plywood mills processing residues are generated in the form of veneer cores, defective ends and irregular pieces of veneer sheets. Secondary processing residues are produces during the process of planning mills, moulding plants and furniture factories in the form of sawdust, plane shavings, small pieces of lumber trimming, edging, bark and fragments. Estimated amounts of residues generated by the forest in Malaysia are presented in Table 16.

2.3. Municipal solid wastes (MSW)

MSW in Malaysia is disposal of 98% of total wastes mainly as household wastes, industrial and commercial wastes. These wastes are capable of producing landfill gas (LFG) comprising of methane (CH_4), carbon dioxide (CO_2) and greenhouse gases (GHG) [25]

Table 13
Agricultural land use, 1995–2010 (‘000 ha) [23].

Item	1995	2000	2005	2010	Average annual growth rate (%)			
					1995–2000	2000–2005	2005–2010	1995–2010
Rubber	1690.0	1490.0	1395.0	1185.0	–2.5	–1.3	–3.2	–2.3
Oil Palm	2540.0	3125.0	3461.0	3637.0	4.2	2.1	1.0	2.4
Cocoa	190.0	130.0	130.0	130.0	–7.3	0.0	0.0	–2.5
Paddy	670.0	660.0	475.0	450.0	–0.3	–6.4	–1.1	–2.6
Coconut	250.0	180.0	180.0	180.0	–6.4	0.0	0.0	v2.2
Pepper	10.0	11.0	11.0	11.0	1.9	0.0	0.0	0.6
Vegetables	42.0	48.0	64.0	86.0	2.7	5.9	6.1	4.9
Fruits	260.0	290.0	330.0	375.0	2.2	2.6	2.6	2.5
Tobacco	11.0	11.0	11.0	11.0	0.0	0.0	0.0	0.0
Others	106.0	130.0	150.0	180.0	4.2	2.9	3.7	3.6
Total	5769.0	6075.0	6207.0	6245.0	1.0	0.4	0.1	0.5

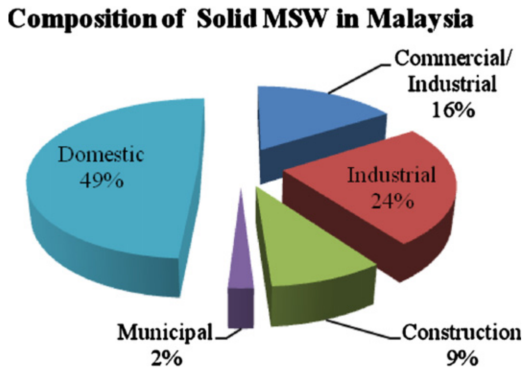

Fig. 3. Composition of solid MSW in Malaysia [27].

which can be used efficiently for power generation, transportation and food industries. Currently there are over 261 landfill sites in Malaysia [8].

Municipal solid waste (MSW) generation had increased from 16,200 tonnes in 2001 to 19,100 tonnes in 2005 or at an average of 0.8 kg per capita per day. It is projected to be 30,000 tonnes by 2020 [26]. Basically, solid waste management can be defined as a discipline to co-ordinate the control and disposal of solid waste. Despite the drastic economic development in Malaysia, solid waste management is relatively poor. Waste minimization in Malaysia strives to achieve the UN Agenda 21 in relation to control the strategy.

Fig. 3 shows the composition of MSW in Malaysia, while Fig. 4 illustrates solid waste composition of selected area in peninsular Malaysia.

In 2006, it was estimated 7.34 million tonnes of solid wastes were generated in Malaysia. Based on data, released by Statistic Department (SD) in 2007, Kuala Lumpur with population of 1.604 million is a leading contributor of solid waste generating from 2620 tonnes in 1995 to 3070 tonnes in 2000. It has produced about 4000 tonnes of solid waste per day in 2000 [28]. The amount of solid waste is increasing every year due to increasing in population, accelerated of urbanization and industrialization process. Table 17 shows projected amount of MSW generated by 2020.

Air Hitam Sanitary Landfill located at Puchong at a landfill area is the landfill gas (LFG) power generation with capacity of 2.096 MW. Construction of the site was completed in November 2003 and it was commissioned in April 2004. The landfill area is as large as 58 ha and receives 3000 tonnes of garbage/day from the Klang Valley. A TNB substation is located as near as 30 m from the site. It can feed 2 MW of the generated energy to the public grid.

State of Trengganu has installed the biggest municipal solid waste combustor system in the country with capacity of 100 tonnes/day, which is capable of supplying 1.5 MWe to the public grid [18].

In December 1997, Kyoto Protocol is adopted at Conference of the Parties at its 3rd session (COP 3) in Kyoto, Japan. The main objective is to reduce the emissions of 6 GHG for industrialised countries. The 6 types of GHG with different global warming potential (GWP) are carbon dioxide (CO_2) with GWP of 1, methane (CH_4) with GWP of 21; nitrous oxide (N_2O) with GWP of 310; sulphur hexaflouride (SF_6) with GWP of 23,900, hydrofluorocarbon (HFC) with GWP of 11,700 and perfluorocarbon (PFC) with GWP of 9200. The GWP is usually expressed in CO_2-equivalent [29].

The Kyoto Protocol sets the targets for 5 years period starting from 2008 until 2012 (1st commitment period). According to this Protocol, there are 3 market mechanisms towards GHG emission reduction: Clean Development Mechanism (CDM) under Article 12, Emissions trading under Article 17 and Joint Implementation (JI) under Article 6. In November 2001, the adoption of legal documents of operational rules (Marrakesh Accords) at the 7th Session of the Conference of the Parties (COP7) to the United Nations Convention on Climate Change in Marrakech, Morocco. On 16th February of 2005, the Kyoto Protocol entered into force [29,30].

2.3.1. Clean Development Mechanism (CDM)

CDM projects are the projects that have potential to reduce GHG in Malaysia. As Malaysia is non-Annex 1 country, it can employ the CDM to reduce domestic CO_2 emissions in addition to transferring advanced technologies from highly developed countries [8].

In fact, there are transaction cost to register a project as a CDM project before the tradable CERs (Certified Emission Reductions) can actually be generated. The cost varies from USD 40,000 to USD 150,000 for a project [31]. Table 18 shows an overview of the expected potential of CER revenues.

Host country approval can be officially registered as CDM projects and generate CERs. Without such approval, no CERs can be generated. If Malaysian government does not want to support a certain projects, it can withhold national approval and thus, CERs cannot be generated and traded [31].

According to the PTM, there are 4 examples of CDM projects [31]. The first is renewable energy project which basically use hydropower or biomass to generate electricity. Secondly, the Fuel Switch project where coal burning installation is replaced by natural gas or biomass. The third is in improving the energy efficiency by replacing current production motors with more energy efficient motor and also replacing existing equipment for generating power and heat separately with cogeneration equipment, and eventually the biogas project which cover landfill sites to capture the methane and burn it to generate the energy.

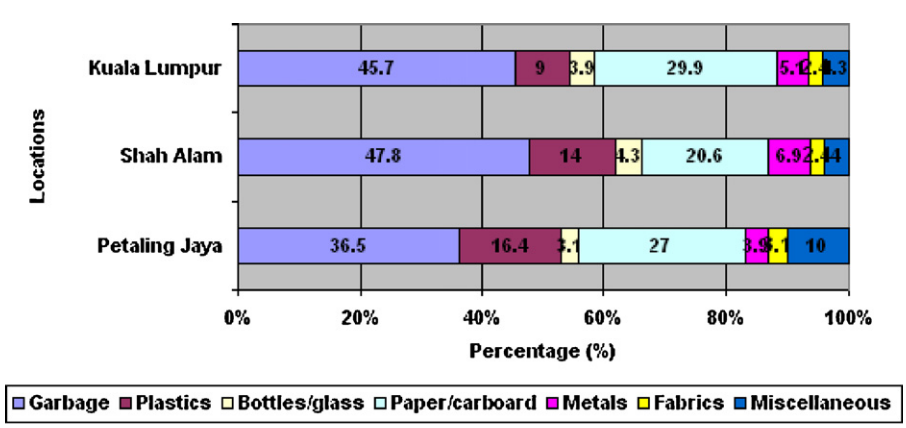

Fig. 4. Solid waste composition of selected locations in Peninsular Malaysia [16].

Table 14
Land area under natural forest and agriculture in Malaysia [17].

	Million ha	% of land area
Natural forest	20.10	61.0
Agriculture	4.89	14.9

During the first quarter of 2009, the number of CDM applications in Malaysia which were successfully registered with CDM executive board was 34, but only 5 projects with Carbon Emission Reduction certificates (CERs) valued about RM 12.3 million were issued, which are Lahad Datu Edible Oil biomass steam and power plant, Sandakan Edible Oil biomass steam and power plant, Felda Sahabat empty fruit bunch biomass energy project, replacement of fossil fuel by palm kernel shell for the production of Portland Cement and Biomass energy project at Lumut, Perak [32].

2.4. Bio-fuels

Currently, there are 5 types of bio-fuels using oil palm biomass as the source: bio-ethanol, bio-methanol, bio-briquettes, hydrogen gas and pyrolysis oil.

Generally, bio-ethanol fuel is the production of fermentation process of grains which contains sugar such as EFB that is rich in sugar. This process is very similar to brewing method [20]. Flexible-fuel vehicles run on fuels which contains 85% bio-ethanol [7]. The use of bio-ethanol as fuel addictive is normally to cut down on vehicle's carbon monoxide and other smog-causing emission. Flexible-fuel vehicles which run on mixture of gasoline and 85% of ethanol are now available in Brazil, US and European market [20].

The bio-methanol is most suitable in case of application in spark ignition engines due to its high octane rating and most likely to be approach method in converting into bio-methanol is gasification; however, the demand for bio-ethanol and bio-methanol as alternative fuel in Malaysia is still low due to familiarity in running on petrol [20]. Therefore, bio-ethanol and bio-methanol production are not improved due to undeveloped technology to make it commercialize even though there is an opportunity for the production to be commercialize [33].

Briquetting process is an alternative method in converting biomass into a uniform and solid fuel. In this method, empty fruit bunches (EFB) and palm kernel expeller (PKE) used to be densities into briquettes at high temperature and pressure using screw extrusion technology. The benefits of using this method include low cost, all year round availability, high calorific value, longer burning duration and more environment friendly [20].

Hydrogen is synthetic fuel which is exploited from different kinds of energy sources, for instance fossil fuels, nuclear energy and biomass. The major benefit of using hydrogen as fuel is higher engine efficiencies.

Hydrogen use in Malaysia is mainly derived from either steam reforming of natural gas (NG) in the oil, gas and petrochemical industries or electrolysis in oleo-chemical processing industry,

Table 16
Quantity of residues generated by the foresty industry [17].

Source	Million m^3
Logging residues	5.10
Primary manufacturing residues	2.92
Plywood residues	0.91
Secondary residues	0.90
Total	9.83

Table 17
Projected amount of MSW generated by 2020 [19].

Year	Population	Estimated amount of waste (tonnes/year)
1991	17,567,000	4,488,369
1994	18,917,739	5,048,804
2015	31,773,889	7,772,402
2020	35,949,239	9,092,611

Table 18
Overview of the expected potential of CER revenues [29].

Project type	CERs per year (2010)	MW electricity
Biogas POME + animal manure	5,900,000	190
Landfill gas	3,700,000	45
Reduction of gas flaring from oil production	4,600,000	N/A
Mini hydro	70,000	25
Biomass CHP	380,000	90
Other projects	3,150,000	N/A
Total	17,800,000	350

Table 15
Malaysia: quantity export of major timber products, 2007 until 2008 (m^3) [16].

Year	2007		2008	
	Quantity	FOB value (RM)	Quantity	FOB value (RM)
Logs	4,647,429	2,111,987,326	3,493,935	1,691,600,064
Sawn timber[a]	4,487,340	3,159,831,928	1,565,653	2,182,420,170
Sleepers	15,652	18,936,121	11,675	12,611,696
Veneer	333,815	389,982,858	338,548	354,239,906
Mouldings[b]	341,818	915,314,887	214,472	546,868,390
Chipboard/Particleboard	472,426,857	364,983,609	565,482	349,018,042
Fibreboard	1,125,975	1,180,917,563	971,159	978,073,911
Plywood[c]	4,372,034	6,274,137,563	3,986,938	5,351,240,774
Wooden frame	12,439,543	132,195,786	9,058,527	107,021,571
BCJ (builders joinery and carpentry)	n.a.	1,017,594,173	171,016,476	836,165,680
Wooden furniture	n.a.	6,664,885,981	n.a.	5,673,047,700
Rattan furniture	n.a.	50,479,548	n.a.	43,394,317
Other timber products[c]	n.a.	483,043,534	n.a.	406,357,182
Grand total[d]	n.a.	22,764,290,877	n.a.	18,532,059,403

[a] Sawn timber includes dressed timber.
[b] Other timber products include fuel wood, wood charcoal, hoop wood, wood wool and wood flour, packing cases, cask, barrel, vat and tubs, tool bodies and handles, tableware, kitchenware, wood marquetry and other articles of wood.
[c] Plywood includes blockboard.
[d] Grand total does not include shipment between Peninsular Malaysia, Sabah and Sarawak.

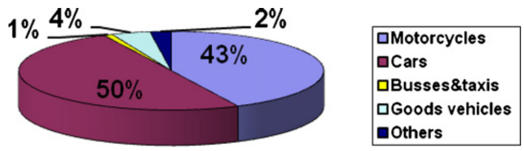

Fig. 5. Number of new motor vehicles registered from 1996 to 2008 [31].

metal cutting and welding works. However, the production of hydrogen as synthesis fuel is still at early stage of research [20].

Pyrolysis oil is basically a kind of tar which can be extracted from dried biomass. This technique is still at infancy stage as a substitute for petroleum. Pyrolysis oil derived from EFB is rich in carbon which is a kind of substitute in crude petroleum which has potential feedstock for fuels and chemicals' production in petroleum fuels. Recently, Genting Sanyen Bhd in conjunction with Biomass Technology Group (BTG) has completed the first pyrolysis plant in Malaysia as a breakthrough step for Malaysia to use oil palm biomass as source of pyrolysis oil [20]. Energy demand for transportation has reached 180,274 GJ/day at Malaysia in 2007. Table 19 shows the Malaysia's population and bio-ethanol demand [2].

The Malaysia's government has experienced bio-diesel in transportation sector to ensure the sustainable energy for the future energy supply. In 1982, bio-diesel was exploited from palm oil by Malaysian Palm Oil Board (MPOB) [34].

There are 2 ways of using palm oil as fuel in power vehicles: using vegetable oil directly in diesel engine and by converting the oil into methyl ester [34]. By 2007, 92 projects were approved with capacity of 0.5 million tonnes/year; however, construction of only 14 plants with capacity of 47,790 tonnes was completed (in 2006), followed by 95,010 tonnes (in 2007) and by 2008, no more than 6 plants remained operating. By 2008, Malaysia was producing 500,000 tonnes/year of bio-fuel [7]. The National Bio fuel Policy (2005) introduced a biodiesel fuel blend (B5) in late 2009. According to PTM, the Malaysian government will establish biodiesel B5 standards and deploying biodiesel at selected petrol stations. The biodiesel failure in Malaysia is mainly due to the competition from the food industry and the high price of palm oil so the alternative method is by extracting biodiesel from Jatropha oil instead of palm oil [34].

There is a bio-energy project located in Kunak, Sabah with the capacity of 14 MW, where, 10 MW are to be sold to Sabah Electricity Sdn. Bhd. (SESB). The fuel generated are mainly from oil palm residues in the form of empty fruit bunches (EFB), shells and fibers. It is expected to produce around 40,000–50,000 tonnes of carbon dioxide, annually [35]. Table 20 provides list of biomass plants in Malaysia.

Table 21 represents the consumption of bio-fuel registered vehicles from 1996 to 2008. Approximately 5% of the motor vehicles in Malaysia use bio-fuel [33]. Fig. 5 provides the rough percentage of new motor vehicles registered from 1996 to 2008.

2.5. Bio-power

Bio-power is the generation of electrical energy from biomass sources. There are five types of bio-power technologies: direct-fired, gasification, anaerobic digestion, pyrolysis, and small scale systems. In direct-fired technology which usually uses EFB and MF, heat energy is generated of burning or direct combustion of wastes and then detains to rotate a power generator. In gasification process, ligno-cellulosic biomass is turned into hydrogen gas.

The first power plant to produce electricity using the biomass was first announced by government of Malaysia intention to enhance the study on the feasibility of applying the Felda Plant model throughout the biomass sector. Felda Palm Industries Sdn. Bhd. (FPISB) operates 7.5 MW integrated biomass co-generation plant at palm processing facility. A budget of about RM38 million has been allocated for biomass construction by Felda Sahabat plant which started in August 2003 and began to operate in October 2006 [37].

Presently, the majority of palm oil mills make full utilization of waste fibers and shells which contains oil, to generate electrical power and also as boiler fuel to produce steam for mill consumption and extracting crude palm oil (CPO). In association with decreasing GHGs in Malaysia, Chubu Electric Power has announced for construction of 2 biomass power plants with 2 MnT/year reduction of CO_2 in Sabah. Proposed power plants are capable to generate 10,000 kW electric power by making full utilization of palm bunch wastes. Another project is located in Pantai Remis, Perak by Bumi Bio-power Sdn. Bhd, is a biomass power plant with capacity of 11.5 MW, which combusts EFB in a boiler to produce electricity [7].

From financial standpoint, gasifier based generation from biomass energy is more cheaper, efficient and competitive in comparison with fossil fuel based power generations especially in remote and isolated areas with small scale power generation; however for the large-scale power plants the price is competitive with coal-based generation or electricity from the grid [1].

3. Plan and strategies to promote biomass use in Malaysia

Several supporting measures have been set for promoting renewable energy utilization in Malaysia such as electricity feed-in tariff at 21 cents/kWh for biogas and biomass, Small Renewable Energy Power (SREP) program and Renewable Energy Power Purchase Agreement (REPPA). Implementation of Small Renewable Energy Power (SREP) program has been launched on 11th May 2001 with the objective to encourage the utilization of renewable energy in power generation with the target of 5% in total electricity generation by 2005. The total capacity installed is 500 MW. In SREP, the small power generation plants were used to sell the electricity utility through the distribution grid systems. It allowed all types of renewable energy including biomass, biogas, municipal solid waste, solar, mini-hydro and wind. The capacity for sale is as much as 10 MW [38]. Table 22 is status of SREP projects approved by SCORE as at August 2004.

To make biomass utilization more efficient, a Special Committee on Renewable Energy (SCORE) was set up by Ministry of Energy, Water and Communication to coordinate the program and act as one-stop centre at Energy Commission facilities industry participation. During the program, 65 projects were approved out of 115 applications; however in 2009, only 4 biomass power plants with the capacity of 35.5 MW, 1 biogas with the capacity of 2 MW and 2 mini-hydro power plants with capacity of 8 MW were connected to the grid [34].

Implementation of the Biomass-based Power Generation and Co-generation in Malaysian Palm Oil Industry (BioGen) involves the implementation of barrier-removal activities in Malaysia. The BioGen project represents collaboration between United Nationals Development Program (UNDP) and Global Environment Facility (GEF) with Malaysian Government and other private organisations [38]. In 2009, there were 2 full scale demonstration model plants with capacity of 13MW biomass and 0.8 MW biogas; however, the major problems are the competitive oil palm biomass use in manufacturing industry and the increased of FiT in biomass and biogas field, from 17 cents/kWh up to 21 cents/kWh [34].

First grid connected biomass based power generation project from palm oil industry was conducted by TSH Bio-Energy (TSHRB) at Kunak, Sabah. It was expected to sell 14 MWe of the renewable energy from oil palm to Sabah Electricity Sdn. Bhd. (SESB) at 21.25 cent/kWh through a 21 years Renewable Energy Power

Table 19
Malaysia's polulation and bio-ethanol demand [32].

State	Population	Energy demand for transportation (GJ/day)	%	Area of oil palm plantation (ha) [22]	%	Bio-ethanol demand (tonnes/day)
Johor	3,101,200	21,480	11.9	595,524	15.8	796
Kedah	1,848,100	12,800	7.1	71,934	1.9	474
Kelantan	1,505,600	10,428	5.8	79,146	2.1	386
Labuan	83,500	578	0.3	-	0.0	21
Melaka	713,000	4938	2.7	45,816	1.2	183
N. Sembilan	846,300	5862	3.3	149,879	4.0	217
Pahang	1,427,000	9884	5.5	563,809	15.0	366
Perak	2,256,400	15,628	8.7	323,535	8.6	58
Perlis	224,500	1555	0.9	258	0.0	377
Pulau Pinang	1,468,800	10,173	5.6	13,010	0.4	579
Sabah	2,931,700	20,306	11.3	1,151,698	30.6	752
Sarawak	2,312,600	16,018	8.9	513,306	13.6	593
Selangor and Putrajaya	4,736,100	32,804	18.2	120,563	3.2	1215
Terengganu	1,016,500	7041	3.9	135,911	3.6	261
Kuala Lumpur	1,556,200	10,779	6.0	–	0.0	399
Total	26,027,500	180,274	100.0	3,764,389	100.0	6677

Table 20
List of biomass plants in Malaysia [31].

Plant/owner/operator	State	MW	Type	Fuel
TSH Bio Energy Sdn Bhd	Tawau, Sabah	14	Steam turbines	Empty fruit bunch
Jana Landfill Sdn Bhd	Seri Kembangan, Selangor	2	Gas turbines	Biogas
Bumibiopower Sdn Bhd (planning approved 2001)	Pantai Remis, Perak	6	Steam turbines	Empty fruit bunch
Potensi Gaya Sdn Bhd (planning approved 2003)	Tawau, Sabah	7	Steam turbines	Empty fruit bunch
Alaf Ekspresi Sdn Bhd (planning approved 2003)	Tawau,Sabah	8	Steam turbines	Empty fruit bunch
Naluri Ventures Sdn Bhd(planning approved 2005)	Pasir Gudang, Johor	12	Steam turbines	Empty fruit bunch
Kina Biopower Sdn Bhd (planning approved 2007)	Sandakan, Sabah	11.5	Steam turbines	Empty fruit bunch
Recycle energy Sdn Bhd (planning approved 2007)	Semenyih, Selangor	8.9	Gas turbines	Biogas
Seguntor Bioenergy Sdn Bhd (planning approved 2007)	Sandakan, Sabah	11.5	Steam turbines	Empty fruit bunch

Table 21
Potential Consumption of bio-fuel registered vehicles used (1996–2008) [36].

Motorcycles	Cars	Busses and taxis (hire and drive cars)	Goods vehicles	Others	Total
4,475,675	5,215,718	99,052	430,006	234,632	10,455,083
42.81%	49.89%	0.95%	4.11%	2.24%	100%

Purchase Agreement (REPPA) which is the first Palm-EFB-Fired grid-connected cogeneration plant with a high pressure modern boiler of 80 tonnes/h, kk. 5 bar (g) and 402 °C in the world and also the first EFB-Fires broiler employing the well-proven vibrating membrane grate in southeast Asia [38].

In Malaysia local authorities are liable in development of biomass and biogas. Although currently there is no significant research on biomass and biogas due to its availability in commercial stage in the country, there are some research groups on biodiesel and hydrogen energy in almost all universities in Malaysia. In biodiesel field, research on Jatropha oil extraction and heterogenous catalyst of Jatropha oil transesterification and esterification is done at department of chemical and process engineering at UKM. The research on heterogeneous catalyst and supercritical fluid processing of Jatropha oil transesterification and esterification is done in school of chemical engineering and school of chemistry in USM. There are other investigations on biodiesel field by smaller biodiesel/biofuel groups in other universities in Malaysia such as University Putra Malaysia (UPM), University Malaya (UM), University Technology Malaysia (UTM), University Technology Petronas (UTP), International Islamic University (IIU) and University Malaysia Sabah (UMS) [34].

In the field of hydrogen energy, fuel processing groups at fuel cell institute UKM and UTM are working on auto-thermal reforming catalysis of methane, alcohols and hydrogen storage by nano-structured carbon. In addition, there are researches on dark and

Table 22
Status of SREP projects approved by SCORE as at August 2004 [27].

No.	Type	Energy resource	Approved application	Generation capacity (MW)	Grid-connected capacity (MW)
1	Biomass	Empty fruit bunches	22	200.5	165.9
		Wood residues	1	6.6	6.6
		Rice hunk	2	12.0	12.0
		Municipal solid waste	1	5.0	5.0
		Mix fuels	3	19.2	19.2
2	Landfill gas		5	10.2	10.0
3	Mini-hydro		26	99.2	97.4
4	Wind and solar		0	0	0.0
	Total		60	352.70	316.1

light anaerobic fermentation of wastewater such as Palm Oil Mill Effluent (POME) to produce hydrogen by Biohydrogen Group at Fuel Cell Institute UKM and UPM [34].

4. Conclusion

Biomass can be considered as a sustainable substitute for fossil fuels in Malaysia where about 76% of lands are covered by dense tropical forests and agricultural fields. Presently, there is an immense interest in biomass utilization to produce energy due to bio-resource sustainability, environmental concerns and economic reflection. Hence, continuous efforts and researches are focused to improve technologies which produce bio-fuel and bio-power; whereby numerous agricultural and forest residues are capable to turn into useful energy and applicable products. Malaysian government has put significant effort to establish biomass projects including CDM. Government also supported these projects with subsidy. However, there are still major barriers to develop biomass technology extensively in the country such as lack of information for using biomass as an alternative to generate electricity, risk probabilities associated with applying new technology, financial and monetary concerns of producing energy with higher cost compared with conventional energy generation, market demand, pace of commercialization, and deficient in government policy to encourage and fascinate the communities and industries to use biomass. Future use of biomass is totally dependent on the cost of producing energy from biomass compared to fossil fuels and realization of environmental impacts caused by fossil fuels.

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